UNIVERSIDAD PONTIFICIA ICAI ICADE COMILLAS MADRID

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA

# DEA-GITI-432 Digital Control

**SEMESTER:** Fall

**CREDITS:** 6 ECTS (4 hrs. per week: 2.7 Theory + 1.3 Lab, on average)

**LANGUAGE:** Spanish

**DEGREES:** GITI

## Course overview

This course is an advanced control course that focuses on computer-controlled systems, both PID and state-space controllers. The issues involved in the implementation of a PID in a microcontroller are analyzed and a method to take into account these issues is presented. The modeling and control design of dynamic systems in state space is also studied. All the theoretical concepts are illustrated in the laboratory sessions using a self-balancing vehicle.

## Prerequisites

Basic knowledge of Laplace Transform and a basic course on linear control systems.

## Course contents

### Theory:

1. Introduction to digital control systems. General scheme of a digital control system. Comparison between continuous and discrete-time controllers.
2. Discrete-time signals and systems. Concept of discrete-time signal and system. Z transform: definition, properties and transform of basic signals. Inverse Z transform. Discrete-time system: difference equation and transfer function. Relationship between time response and transfer function poles. Stability. Steady state response of stable systems.
3. Discrete-time feedback control systems. Effect of the output sampling and the control signal hold: approximation by a modified continuous model. Proportional control and influence of the sampling period. Exact discretization of the plant by a zero-order hold. Models for analysis and simulation of digital control systems. Dead-beat controllers.
4. Design and implementation of a discrete-time PID controller. Review of PID design by frequency response. Discretization methods for the controller: approximation of the integral and derivative terms.
5. State-space modeling. State-space linear and non-linear models. Electric and electronic circuits. Translational and rotational mechanical systems. Thermal

systems. Hydraulic systems. Operating point and linearized model. Relationship between state-space model and transfer function.

6. Discrete-time state-feedback controllers. Exact discretization of a state-space continuous-time model. Design of a state-feedback regulator by pole placement. Methods for reference tracking: gain adjustment or integral action. State estimation: full and reduced-order observers.
7. State estimation. Open-loop estimator. Closed-loop estimators: full and reduced-order observers.

### Laboratory:

There will be ten 2-hour sessions organized in two projects. The evaluation of each project consists of an exam and a competition among different teams.

**P1.** Design of a digital speed controller (PID and dead beat) for a vehicle.
**P2.** Design of a digital state-feedback controller for a self-balancing vehicle.

## Textbook

- F. Luis Pagola. Control Digital. Universidad Pontificia Comillas, 2012
- N. S. Nise. Control Systems Engineering, 6th Edition. John Wiley and Sons. 2011.

## Grading

The following conditions must be accomplished to pass the course:

- A minimum grade in the final exam of 5 over 10.
- A minimum grade in the laboratory of 5 over 10.

The overall grade is obtained as follows:

- Final exam 45%.
- Other exams 15%. Typically, there are 3 short exams (1-hour long).
- Lab 40%.